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Four new records of *Rhizocarpon* from China

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Abstract — Four new lichen records are reported from China: *Rhizocarpon hochstetteri*, *R. parvum*, *R. polycarpum*, and *R. pusillum*. Detailed taxonomic descriptions with photos and comments are provided.

Key words — *Rhizocarpaceae*, Asia, taxonomy

Introduction

Rhizocarpon Ramond ex DC. is a large genus of c. 200 species included in the family *Rhizocarpaceae*. It is widely distributed in all parts of the world (Matwiejuk 2008). *Rhizocarpon* species frequently occur on siliceous rocks (some on basic substrata) in alpine and polar regions, while other species are parasitic on other lichens (Timdal & Holtan-Hartwig 1988).

The main characters of *Rhizocarpon* are an areolate or rimose thallus, black lecideine apothecia between areoles, *Rhizocarpon*-type asci, 1-septate to muriform ascospores with haloes, brown hypothecium, and anastomosing and branched paraphyses (Feuerer & Timdal 2004, Fletcher et al. 2009). The genus is usually divided into two subgenera: *R.* subg. *Rhizocarpon*, containing species characterized by a yellow thallus containing rhizocarpic acid and *R.* subg. *Phaeothallus* for species with a white, ashy, smoky, or brown thallus lacking rhizocarpic acid (Thomson 1967).

Thirty-one *Rhizocarpon* species have been reported from China (Aptroot & Sparrius 2003, Guo 2005, Li et al. 2013, Mahire et al. 2015, Wei 1991, Zhao et al. 2013). The four new records reported here are from different parts of China; *R. parvum* and *R. pusillum* are yellow lichenicolous species with rhizocarpic acid in the thalli, whereas *R. hochstetteri* and *R. polycarpum* are non-yellow non-lichenicolous species without rhizocarpic acid.

Materials & methods

The specimens are preserved in the Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). Their morphological and anatomical characters were examined under a stereomicroscope (Olympus SZ) and a polarizing microscope (Olympus CX21). Both thallus and medulla were tested with K (a 10% aqueous solution of potassium hydroxide), C (a saturated solution of aqueous sodium hypochlorite), I (a 10% aqueous solution of aqueous potassium iodide), and P (a saturated solution of *p*-phenylenediamine in 95% ethyl alcohol) for identification. The lichen substances were identified using standardized thin layer chromatography techniques (TLC) with system C (Orange et al. 2010). Photos of these lichens were taken under Olympus SZX16 and BX61 with DP72.

Taxonomic descriptions

Rhizocarpon hochstetteri (Körb.) Vain.,
Acta Soc. Fauna Fl. Fenn. 53(1): 280 (1922) Fig. 1

Morphology — Saxicolous, thallus grey-brown, areolate or rimose, 0.1–0.3 mm thick; medulla I–; prothallus visible along the margin; areoles flat to convex, sometimes verrucose, 0.35–0.75 mm diam. Apothecia black, flat to slightly convex, 0.5–1.0 mm diam., irregular, round to angular, sometimes a few small ones clustered in groups, sessile or innate among the areoles; margin prominent, flexuous; exciple dark brown, poorly formed; hyphae radiating; epihymenium Macrocarpa-green (K–, N+ red); hymenium colorless, I+ blue, 100–150 μm high; hypothecium dark brown, paraphyses branched and anastomosing, apices swollen with brown cap; no crystals in the apothecia. Asci clavate, *Rhizocarpon*-type; ascospores colorless, but sometimes pale brown when old, 1-septate, halonate, (19–)22–27 × 9–12 μm, 8 per ascus.

Chemistry — Medulla K–, C–, P–. Stictic acid detected by TLC.

Specimens examined: **CHINA**. **Jilin**, Baishan, Mt. Changbaishan, alt. 2300 m, on rock, 22 Jul. 2014, W.C. Wang 20141058, 20141092, 20141115 (SDNU).

Distribution — *Rhizocarpon hochstetteri* has been reported from Europe, North America, New Zealand, Ukraine, and Japan (Fletcher et al. 2009, Fryday 2002, Galloway 2007, Matwiejuk 2008, Thomson 1997, Timdal & Holtan-Hartwig 1988). New to China.

Comments — *Rhizocarpon richardii* and *R. polycarpum* are two other species with large, colorless, 1-septate ascospores like *R. hochstetteri* but differ in having an I+ blue medulla. *Rhizocarpon cinereovirens* resembles *R. hochstetteri* but is distinguished by possession of norstictic acid and a more areolate thallus. *Rhizocarpon lavatum* and *R. reductum* are usually difficult to distinguish from *R. hochstetteri* because they share the same habitat and their thallus are all grey to grey-brown, but *R. hochstetteri* has 1-septate ascospores while *R. lavatum* and *R. reductum* both have muriform ascospores.

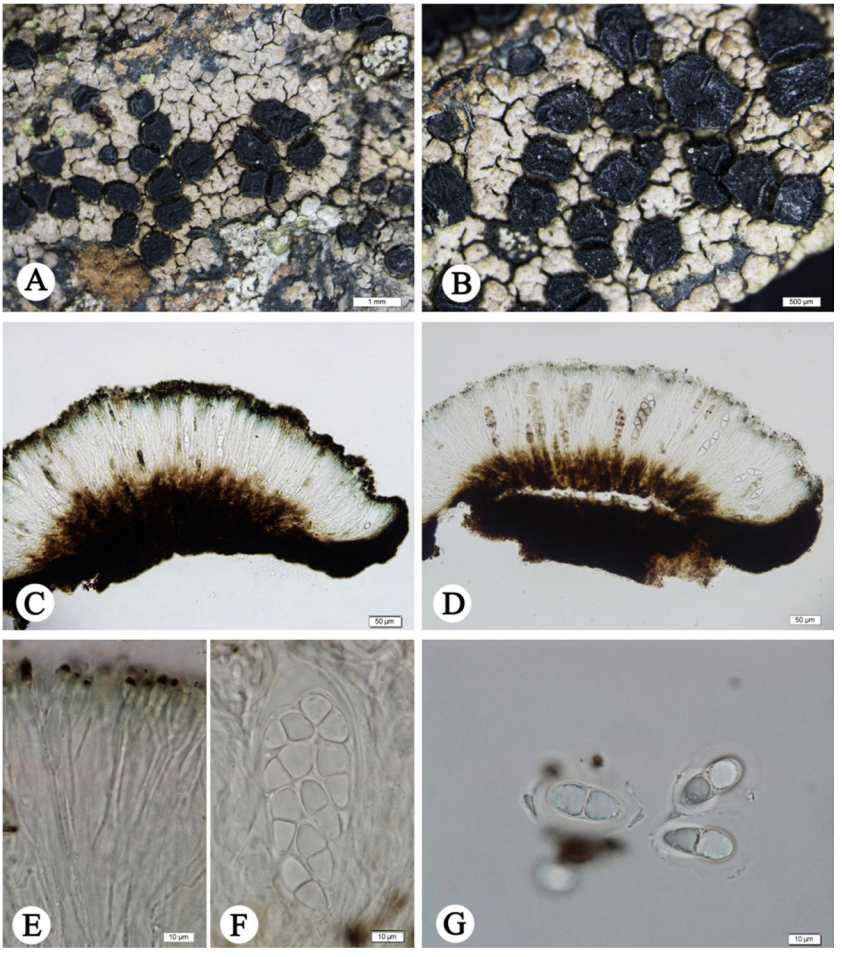

Figure 1. *Rhizocarpon hochstetteri* (Wang 20141058, SDNU). A: Thallus; B: Apothecium; C: Apothecium section; D: K reaction; E: Paraphyses; F: Ascus; G: Ascospores; Scale bars: A = 1 mm; B = 500 µm; C, D = 50 µm; E, G = 10 µm.

Rhizocarpon polycarpum (Hepp) Th. Fr., Lich. Scand. 1(2): 617 (1874) Fig. 2

Morphology — Saxicolous, thallus crustose, areolate, thin, 0.3–0.4 mm thick; medulla I+ blue; prothallus black, evident between the areoles and apothecia and along the thallus margin; areoles dark brown, 0.4–0.6 mm diam., contiguous or scattered. Apothecia black, epruinose, round to angular, 0.4–0.75 mm diam., flat, occasionally flexuose, with a thin, prominent proper

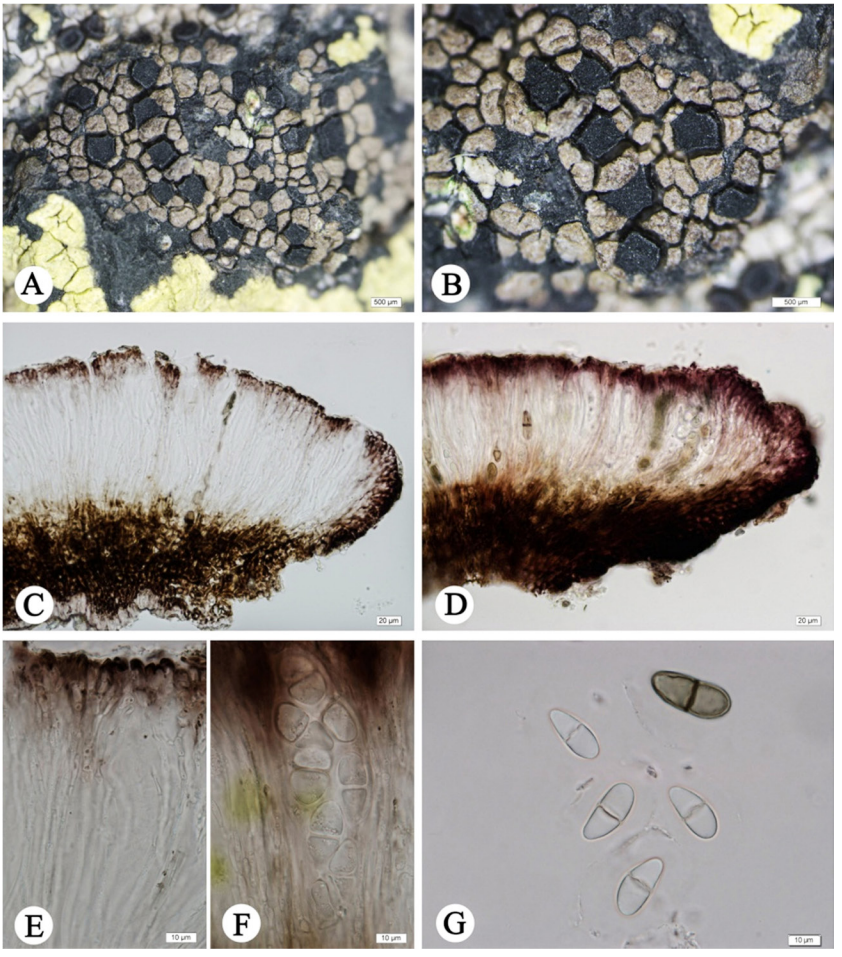

Figure 2. *Rhizocarpon polycarpum* (Wang 20141068, SDNU). A: Thallus; B: Apothecium; C: Apothecium section; D: K reaction; E: Paraphyses; F: Ascus; G: Ascospores; Scale bars: A, B = 500 μm; C, D = 20 μm; E, G = 10 μm.

margin especially when old; exciple brown-black, 45–60 μm; epihymenium red-brown, K+ red-violet; hymenium colorless, 100–110 μm high; hypothecium dark brown, K–, paraphyses branched and anastomosing, no crystals in the apothecia. Asci clavate, *Rhizocarpon*-type; ascospores colorless or sometimes becoming pale brown with age, 1-septate, halonate, 22–26 × 10–11 μm, 8 per ascus.

Chemistry — Medulla K–, C–, P–. No lichen substances detected.

Specimens examined: **CHINA**. **Jilin**, Baishan, Mt. Changbaishan, alt. 2300 m, on rock, 22 Jul. 2014, W.C. Wang 20141068 (SDNU). **Xizang**, Linzhi, Mt. Sejila, alt. 4600 m, on rock, 20 Jul. 2011, Y.L. Cheng 20118355 (SDNU). **Neimenggu**, Aershan, Mt. Jiguanshan, alt. 1500 m, on rock, 29 Aug. 2011, D.F. Jiang 20124660 (SDNU).

Distribution — *R. polycarpum* has been reported from Europe, North America, Australia, New Zealand, Argentina, Asia, and Antarctica. (Anderson 1965, Fletcher et al. 2009, Fryday 2002, Fryday & Kantvilas 2012, Golubkov & Matwiejuk 2009, Øvstedal et al. 2009, Timdal & Holtan-Hartwig 1988). New to China.

Comments — The I+ blue medulla and the red-brown, K+ red-violet epihymenium separate *R. polycarpum* from other species with 1-septate and colorless ascospores. *Rhizocarpon richardii* also has an I+ blue medulla but differs from *R. polycarpum* in having apothecial crystals and a dark olive-green, K– epihymenium. *Rhizocarpon umense,* another species similar to *R. polycarpum,* is distinguished by its brown, distinctly smaller ascospores (12–15 × 5–6 μm) and more reduced thallus.

Rhizocarpon pusillum Runemark, Opera Bot. 2(1): 63 (1956) Fig. 3

Morphology — Lichenicolous, thallus small, 0.3–1.0 cm diam., areolate, forming patches on the host's thallus; medulla I–; prothallus absent or indistinct; areoles bright yellow, round to angular, flat to convex, 0.25–0.75 mm diam.. Apothecia black, round to angular, 0.5–1.0 mm diam., flat to convex, margin present or sometimes indistinct; exciple and epihymenium red-brown, K+ red, no crystals; hymenium colorless, 80–100 μm high; hypothecium brown; paraphyses branched and anastomosing, capitate. Asci clavate, *Rhizocarpon*-type; ascospores blue-brown to dark olive-brown, 1-septate, halonate, 9–14(–15) × (4–)6–7 μm, 8 per ascus.

Chemistry — Medulla K–, C–, P+ yellow. Rhizocarpic acid and psoromic acid detected by TLC.

Specimens examined: **CHINA**. **Xinjiang**, Urumqi, Mt. Tianshan, Glacier No. 1, alt. 3700 m, on *Sporastatia testudinea* (Ach.) A. Massal. on rock, 17 Aug. 2012, D.F. Jiang 20129131 (SDNU); alt. 3560m, on rock, 8 Sep. 2013, Q. Ren 2013897 (SDNU)..

Distribution — *Rhizocarpon pusillum* has been reported from Asia, Europe, North America, and New Zealand (Feuerer & Timdal 2004, Galloway 2007, Matwiejuk 2008, Poelt 1988, Thomson 1997, Timdal & Holtan-Hartwig 1988). New to China.

Comments — *Rhizocarpon pusillum* and *R. parvum* both belong to the yellow *Rhizocarpon* group with rhizocarpic acid in thallus. They are similar in having a small thallus, 1-septate brown small ascospores, and a lichenicolous habit. However, *R. pusillum* is parasitic on *Sporastatia testudinea*, has I– medulla, an indistinct prothallus, and two secondary products (rhizocarpic acid, psoromic acid) detected by TLC while *R. parvum* is parasitic on *Tremolecia atrata*, has

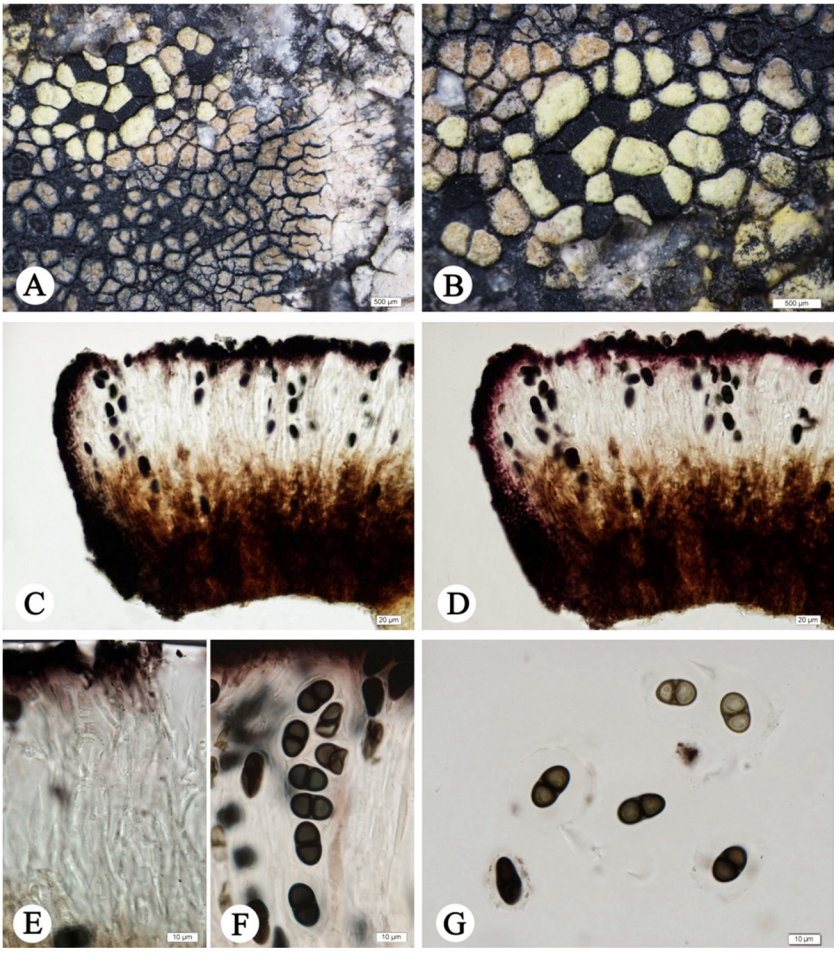

Figure 3. *Rhizocarpon pusillum* (Jiang 20129131, SDNU). A: Thallus; B: Apothecium; C: Apothecium section; D: K reaction; E: Paraphyses; F: Ascus; G: Ascospores; Scale bars: A, B = 500 μm; C, D = 20 μm; E, G = 10 μm.

an I+ violet medulla, a distinctly black prothallus, and rhizocarpic acid without psoromic acid.

Rhizocarpon parvum Runemark, Opera Bot. 2(1): 64 (1956) Fig. 4

Morphology — Lichenicolous, thallus crustose, areolate, small, 0.25–0.75 cm diam.; medulla I+ violet; prothallus distinct; areoles pale yellow, round to angular, 0.1–0.4 mm diam., flat to slightly convex, dispersed on dark prothallus.

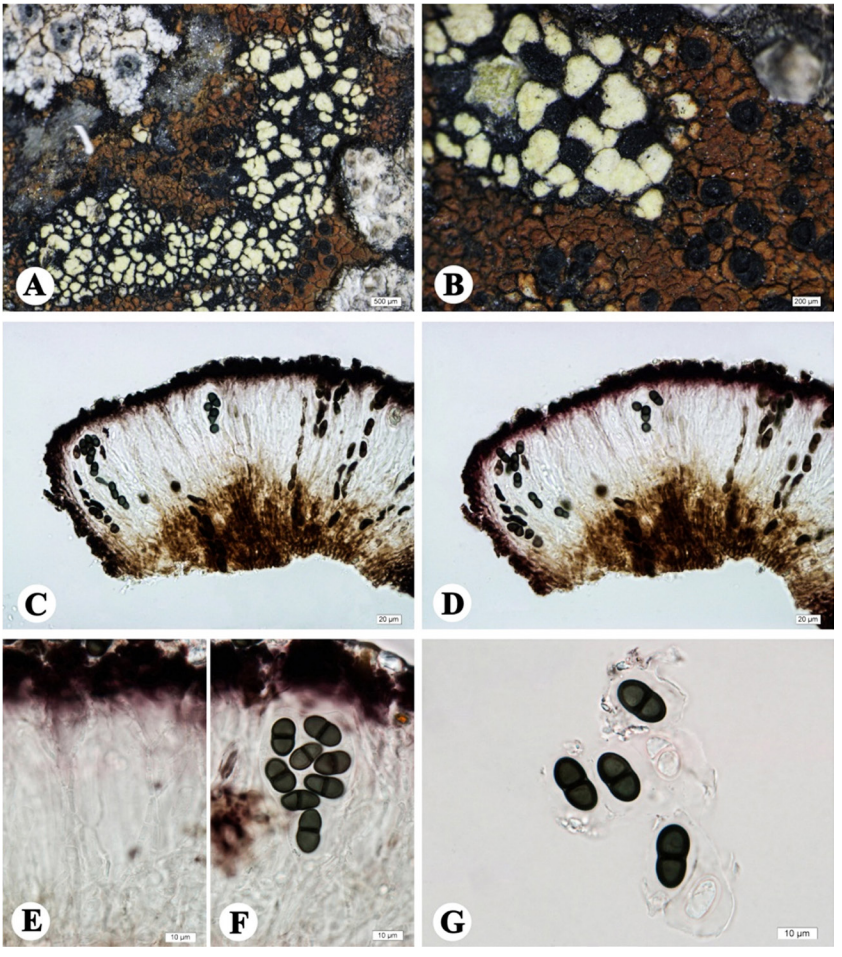

Figure 4. *Rhizocarpon parvum* (Jiang 20129131, SDNU). A: Thallus; B: Apothecium; C: Apothecium section; D: K reaction; E: Paraphyses; F: Ascus; G: Ascospores; Scale bars: A = 500 μm; B = 200 μm; C, D = 20 μm; E, G = 10 μm.

Apothecia black, flat or slightly convex, 0.25–0.6mm diam.; margin distinct; exciple and epihymenium red-brown, K+ red, no crystals; hymenium colorless, 70–90 μm high; hypothecium brown; paraphyses branched and anastomosing, capitate. Asci clavate, *Rhizocarpon*-type; ascospores dark green, 1-septate, halonate, 9–15 × 6–7 μm, 8 per ascus.

Chemistry — Medulla K–, C–, P–. Rhizocarpic acid detected by TLC.

Specimen examined: **CHINA**. **Xinjiang**, Urumqi, Mt. Tianshan, Glacier No. 1, alt. 3700 m, on *Tremolecia atrata* (Ach.) Hertel on rock, 17 Aug. 2012, D.F. Jiang 20129131 (SDNU).

Distribution — *R. parvum* has been reported from Scandinavia (Runemark 1956, Poelt 1988, Timdal & Holtan-Hartwig 1988). New to China.

Comments — *Rhizocarpon parvum* differs from other lichenicolous species with rhizocarpic acid and 1-septate ascospores in having an I+ blue medulla and distinct prothallus.

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